National Academy of Sciences, Engineering, and Medicine
Committee on Seismology and Geodynamics and Its Activities
Final Technical Report
September 23, 2013 to September 22, 2015
Award # G13AP00063
PI: Elizabeth A. Eide

The descriptions below focus on activities that have been accomplished in the project period September 23, 2013 to September 22, 2015. The award has supported the activities of the Committee on Seismology and Geodynamics (COSG; http://dels.nas.edu/global/besr/COSG). This report addresses the following topics

- Summary
- Status of Activities and Progress During the Award Year
  - Ongoing activities
  - Activities in development
  - Communication and engagement
- Outstanding Issues
- Anticipated Activities for FY2016
- Summary of Expenditures

SUMMARY

The Committee on Seismology and Geodynamics (COSG) is a standing committee under the Board on Earth Sciences and Resources. The COSG was formed in 2001 by merging three long-standing committees: the Committee on Seismology, the U.S. Geodynamics Committee, and the Committee on Geodesy. As a standing committee of the Academies, the COSG provides an impartial forum for discussing geophysical issues of importance to federal agencies and scientists and also oversees specialized panels of experts, which carry out scientific studies on issues related to the structure, dynamics, and evolution of the Earth.

The COSG is charged with the following tasks:

1. To foster and encourage understanding of the structure, dynamics, and evolution of the Earth;
2. To review and define basic and applied research activities in seismology, geodesy, and geodynamics that contribute to federal agency missions;
3. To address the transfer of seismological and geodynamics knowledge to areas of public welfare and national need including topics such as earthquake science; geological hazards; energy, mineral, and water resources; national security; global climate change; land-use planning; and public education;
4. To foster long-term national efforts to collect, store, and openly disseminate seismological, geodetic, and geodynamical data of all types;
5. To foster long-term national efforts to monitor geodynamical events as well as nuclear testing treaties using geophysical technologies; and
6. To serve as the U.S. member of the Inter-Union Commission on the Lithosphere.

During the award year, the committee oversaw, convened, and facilitated two public meetings, continued progress on a new consensus study and a meeting of experts, and advanced its public engagement and communication profile. Notably also, the committee itself was newly reconstituted with an entirely new membership early in 2015. These activities are described below. A short summary of anticipated activities in FY2016 is also provided.

STATUS OF ACTIVITIES AND PROGRESS

Committee Membership and Staffing

COSG members are chosen to cover the principal disciplines of geophysics and related fields—including seismology, earthquake engineering, geodesy, geodynamics, geomagnetics, tectonics, crustal dynamics, mantle dynamics, geology, and mineral physics—as well as associated measurement, modeling, and computational methods. The composition of the committee varies over time, allowing the committee to respond to emerging scientific and policy issues. Committee members are appointed for 3-year terms (2-term maximum).

A call for nominations in 2013-14 generated nearly 100 names in core areas of geophysics (e.g., earthquake seismology, geodynamics) and in new areas being explored for potential studies (e.g., volcanology, computational methods). The selection and approval process for new committee members was conducted in 2014 and the new committee was nominated and approved by the President of the National Research Council in late 2014. The new members got fully underway with expert staff guidance from Dr. Deborah Glickson, who assumed the role as staff officer responsible for the committee also in late 2014. The members and their biographies are provided in Appendix 1. The members have embraced their role and the mission of the committee with great energy and enthusiasm and have begun the process of renewing the high level of activity that the committee has had in the past (see more below).

Public Meetings

During 2014, while the nominations process was proceeding, the committee did not hold a public meeting. However, one public meeting was organized during the award year FY2015.

At its **Spring 2015** meeting (see Appendix 2 for the agenda), the first for the newly reconstituted committee, the group took the opportunity to re-engage and familiarize themselves with three of the committee's four primary sponsors: USGS, the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF). The fourth sponsor, the Department of Energy's Office of Science/Basic Energy Science (DOE-BES), was in the process of identifying a new director for the program that oversees the COSG award and was not available to participate. The discussions at that meeting proved to be very beneficial for both the agencies and the committee in reviewing current topics/issues of interest and potential ways in which the committee could be of assistance to the agencies.

Meeting outcomes:

Each of the three agencies expressed continued interest in the upcoming study on Improving Understanding of Volcanic Eruptions (see further description below) which COSG will oversee.

NASA shared its plan to host a workshop in 2015 to review its Earth Surface and Interior strategy, with hope that COSG could be engaged in some productive way.

NSF shared its ongoing work regarding the intent to issue a new solicitation for future management of the seismic and geodetic infrastructure and network facilities. COSG was asked to engage with NSF in the autumn of 2015 in oversight of a meeting of experts to assist NSF with this effort.

Work in Progress

The committee supported the final steps to get a new study underway on "Increasing Understanding of Volcanic Eruptions", a project jointly sponsored by USGS, NSF, and NASA. A second project, the 'meeting of experts' to assist NSF as it seeks to recompete the awards for the seismic and geodetic facilities was developed during the award year, as well. Continued dissemination also occurred with the induced seismicity report. These projects are described below:

- **Improving Understanding of Volcanic Eruptions**: This study aims to improve understanding of the processes that initiate, sustain, and end volcanic eruptions and the relationships between those processes and observed eruption precursors. Sponsors include NSF, NASA, and the USGS. Initially slated to be conducted solely as a workshop instead of a consensus study due to funding constraints on the part of the agencies, the Academies Presidents agreed to provide $150,000 toward the project, enabling the scope to be broadened to a full consensus study. The study thus began in September 2015 and will last approximately 22 months. The slate of nominees to the committee will be finalized in the autumn of 2015 and the work of the committee will begin in earnest in 2016.

  Study statement of task
  An ad hoc committee will examine fundamental research needed to improve understanding of the processes that initiate, sustain, and end volcanic eruptions and the relationships between those processes and observed eruption precursors. In particular, the committee will undertake the following tasks:

  • Summarize current understanding of how magma is stored, ascends, and erupts.
  • Discuss new disciplinary and interdisciplinary research on volcanic processes and precursors that could lead to forecasts of the type, size, and timing of volcanic eruptions.
  • Describe new observations or instrument deployment strategies that could improve quantification of volcanic eruption processes and precursors.
  • Identify priority research and observations needed to improve understanding of volcanic eruptions and to inform monitoring and early warning efforts.

- **Discussion of the National Science Foundation Division of Earth Sciences' Workshop Report on "Future Seismic and Geodetic Facility Needs in the Geosciences": Meeting of Experts**: This short-term project was designed to provide additional input to the NSF's Division of Earth Sciences (EAR) as it prepares to recompete the Seismological Facilities for Advancement of Geoscience and EarthScope (SAGE) and Geodetic Facilities for Advancement of Geoscience and EarthScope (GAGE) programs. The Academies was asked to convene an ad hoc meeting of experts for one day in late October 2015 to

review and provide individual expert opinions on the NSF-generated report from the May 2015 NSF workshop held in Leesburg, Virginia, on this topic.

- **Induced Seismicity Potential in Energy Technologies**: this consensus study report was released in 2012 and published in hardcover form in 2013 (http://www.nap.edu/catalog.php?record_id=13355). The report summarized the state of knowledge on the scale, cause, and consequence of seismicity generated during fluid injection related to energy production; identified gaps in knowledge and research needed to advance the understanding of induced seismicity, its causes, effects, and risks; identified gaps in hazard assessment methods; and identified options for interim steps toward best practices. A YouTube video was also developed for a non-technical audience based on this report (http://www.youtube.com/watch?v=Uuh9lHavdvc). The project sponsor was the U.S. DOE. Although the project concluded in June 2014, continued dissemination of the report occurred by the efforts of members of the original study committee. This project was jointly overseen by the COSG and two sister committees under the Board on Earth Sciences and Resources—the Committee on Earth Resources and the Committee on Geological and Geotechnical Engineering. Through the award period, more than 8,128 unique downloads of the report were recorded, as were more than 3,900 unique views of the YouTube video accompanying the report.

Public Engagement and Communication

The committee will be exploring ways to increase its outreach to and communication with various stakeholders across federal and state government, the private sector, academia, and non-profit organizations. Traditional communication mechanisms used during the award period have included the committee website and study reports and their dissemination. Other mechanisms (through the Board's Twitter account @NASEarth, for example) are also being examined. The committee is also making remote access to its public meetings via WebEx a standard part of its meeting agendas and meeting invitations.

OUTSTANDING ISSUES

Late during the award period, the responsible staff officer, Deborah Glickson, indicated that she would depart the Academies for a new job elsewhere. Staff coverage in FY2016 will be assumed by Dr. Elizabeth Eide, director of the committee's parent Board (BESR). A change in PI will be requested from USGS to reflect this change in staffing. No other issues were noted.

ANTICIPATED ACTIVITIES FOR FY2016

Among the activities the committee will continue to facilitate or convene in FY2016 are:

- Two public meetings (one in October 2015 on the topic of 'Geophysical Research Challenges Spanning the Coastal Zone'; another in April 2016 on education and training initiatives for undergraduates and graduates in high-performance computing)
- Oversight of a 'meeting of experts' for NSF (in October 2015)
- Oversight of a new study:
    - Increasing Understanding of Volcanic Eruptions

Although not as easy to predict or guarantee, the committee also will work toward developing a new study on landslides in collaboration with its parent board and sister standing committees:

- **Advancing Landslide and Debris-flow Identification, Monitoring, and Early Warning:** This study idea is the direct product of interest expressed by several federal agencies following two meetings in FY15 hosted by the Board on the topic of landslides. The idea itself is under development with **Jonathan Godt at USGS** who has also been in communication with NASA and NWS as potential partners in supporting the effort. The focus for the study would be on developing a framework to identify and map landslide susceptibility and hazard using topographic (lidar) data that could be employed at national, state, and local levels.

SUMMARY OF EXPENDITURES

The funds allocated to the committee and its activities were fully utilized and were directed primarily toward staff time in support of the committee's functions.

Appendix 1

COMMITTEE ON SEISMOLOGY AND GEODYNAMICS

2015 MEMBERSHIP
Biographical Sketches

RICHARD M. ALLEN, Chair, is Director of the Berkeley Seismological Laboratory and Professor in the Department of Earth and Planetary Science at UC Berkeley. He is an expert in earthquake alerting systems - developing methodologies to detect earthquakes and issue warnings prior to shaking. His group uses seismic and GPS sensing networks and is experimenting with the use of smartphones. Testing of a warning system for the US west coast is currently under way. Allen's group also uses geophysical sensing networks to image the internal 3D structure of the Earth and constrain the driving forces responsible for earthquakes, volcanoes, and other deformation of the Earth's surface. His research has been featured in Science, Nature, Scientific American, The New York Times and dozens of other media outlets around the world. He has a B.A. from Cambridge University, a M.Sc. from the University of Durham, a Ph.D. from Princeton University, and was a Postdoctoral Fellow at Caltech.

THORSTEN W. BECKER is a geophysicist with main research interests in geodynamics and seismology. He holds a Ph.D. in geophysics from Harvard (2002) and joined the faculty of the University of Southern California, Los Angeles in 2004 after a post-doctoral appointment at Scripps, University of California, San Diego (UCSD). Becker studies the inner workings of terrestrial planets and how their mantle and surface systems have co-evolved over time. He has co-authored more than 85 publications, combining field, laboratory, and numerical approaches into dynamical models, focusing on the physics of plate tectonics, from grain-scale deformation to plate-scale flow. Recent research projects include work on seismic anisotropy, mantle heat transport and the mechanics of plate tectonics, subduction dynamics, and fault system mechanics.

CYNTHIA EBINGER is a professor in the Department of Earth and Environmental Sciences at the University of Rochester. Dr. Ebinger served as a former president of the Tectonophysics Section of the American Geophysical Union (AGU) and was recently named a Fellow of the AGU for her "fundamental work on the evolution of continental rifts toward seafloor spreading in East Africa and Afar." Her current research aims to understand the partitioning of strain between faulting and magmatic processes within continental and oceanic rift zones, over time scales of hours to millennia, and the longer-term evolution of continental rift zones from initiation to continental rupture. Her interest in continental rifts and plate boundary deformation began as an undergraduate at Duke University when she took part in a National Science Foundation (NSF)-sponsored research project in the East African rift where earthquake and volcanic activity continually reshape lake basins and surface topography. As a graduate student

at Woods Hole Oceanographic Institute (WHOI)-M.I.T., she studied oceanic rift zones where continental rupturing occurred millions of years before. She earned her B.S. in geology from Duke University, S.M. from M.I.T., and Ph.D. in oceanography from M.I.T./WHOI Joint Program.

STEVEN (STEVE) JACOBSEN, Associate Professor of Earth and Planetary Sciences at Northwestern University, is a geophysicist specializing in mineral physics. He studies the role of volatiles, especially water, in controlling geophysical processes driving the evolution of Earth's crust, mantle and atmosphere. He developed an ultrasonic technique for the diamond-anvil cell, which measures acoustic velocities in Earth and planetary materials at mantle conditions. By examining the influence of water on material properties and melt generation, Jacobsen is working to map mantle water content from dense regional seismic data, such as the USArray. His research has broader implications for the global geochemical budget and origin of Earth's water. Jacobsen is active in science and development at large-scale user facilities for high-pressure synchrotron research including the Advanced Photon Source at Argonne National Lab and the National Synchrotron Light Source-II at Brookhaven. He served as Distinguished Lecturer of the Mineralogical Society of America and his awards include a Presidential Early Career Award for Science and Engineering (PECASE) and a David and Lucile Packard Fellowship. Jacobsen serves on the Administrative Board of The Graduate School at Northwestern and the Executive Committee of NSF-COMPRES. He is Associate Editor of Geophysical Research Letters. Prior to postdoctoral fellowships at Bayerisches Geoinstitut, Bayreuth, Germany, and the Geophysical Laboratory, Carnegie Institution of Washington, Jacobsen received his Ph.D. in geophysics from the University of Colorado, Boulder.

DENNIS V. KENT (NAS) is Board of Governors Distinguished Professor of Geological Sciences at Rutgers University and adjunct senior research scientist at Lamont-Doherty Earth Observatory. He is an author of 275 widely-cited journal and book articles dealing with paleogeography and paleoclimate, the tempo of geomagnetic polarity reversals and other aspects of Earth magnetism. He is also a fellow of the Geological Society of America, American Geophysical Union, American Association for the Advancement of Science, the American Academy of Arts and Sciences, and an original member of ISI Highly Cited Researchers. Dr. Kent was awarded the Arthur L. Day Medal from the Geological Society of America, the Vening Meinesz Medal from Delft University in Holland, the Petrus Peregrinus Medal from the European Geophysical Union, the William Gilbert Award from the Geomagnetism and Paleomagnetism Section of AGU, and received an honorary doctorate from the Institut de Physique du Globe de Paris-Sorbonne in 2005. He has served on the governing boards of the Joint Oceonagraphic Institutions and International Ocean Discovery Program Management International and as elected president of the Geomagnetism and Paleomagnetism Section of AGU. He presently serves as an elected Member-at-Large of the section on Geology and Geography of the American Association for the Advancement of Science and on the advisory board of the Elsevier journal Earth and Planetary Science Letters. He received his B.Sc. in geology from the City College of New York and his Ph.D. in marine geology and geophysics from Columbia University.

LISA GRANT LUDWIG is Professor for the Program in Public Health at the University of California, Irvine's College of Health Sciences and Social Ecology. She is a former member of

the U.S. National Committee for Geodesy and Geophysics, and she has been a member of two NAS-appointed delegations to international General Assemblies. She is known for her knowledge of public health, natural disasters, and the geological sciences. Dr. Ludwig is interested in the potential disruption of water systems due to seismic quaternary aquifers in the Los Angeles and Orange County region. Her research group addresses natural hazards and disasters from a geologic perspective with an emphasis on earthquakes. She has served as Vice Chair, Board of Directors at the Southern California Earthquake Center from 2007-2011. She has also served as member, Board of Directors of the Seismological Society of America from 2010-2013. Dr. Ludwig received her Ph.D. in geology with geophysics from the California Institute of Technology in 1993.

STEPHEN (STEVE) R. MCNUTT is a volcano seismologist who worked half time for the Alaska Volcano Observatory from 1991-2012. He currently coordinates volcano seismology research for the Department of Geology at the University of South Florida. His research interests include studies of source and propagation effects for volcanic tremor, low-frequency events, and explosion earthquakes; volcanic hazards assessments in Alaska, California, and Central America; the mechanical behavior of volcanoes including periodicity of eruptions; and the effects of earth tides, sea level variations, and tectonic stresses on triggering eruptive activity. From July 1999 to July 2007 he has served as Secretary General for the International Association of Volcanology and Chemistry of the Earth's Interior. He received his B.A. from Wesleyan University in 1977, M.A. from Columbia University in 1982, and Ph.D. in volcanology from Columbia University in 1985.

MATTHEW PRITCHARD is an Associate Professor of Geophysics at Cornell University. He is interested in how the Earth's surface deforms in response to earthquakes, magma movements, glacier dynamics, and human manipulation of subsurface fluids (e.g., carbon sequestration, hydrocarbon withdrawal). Dr. Pritchard uses a variety of tools including Interferometric Synthetic Aperture Radar (INSAR), GPS, and laser scanning to study deformation. He is a member of the American Geophysical Union and the International Association for Volcanology and Chemistry of the Earth's Interior. He served on the UNAVCO Board of Directors from 2009 to 2012 and currently serves on the Advisory Board of the Carl Sagen Institute. He received a B.A. in physics from the University of Chicago and an M.S. and Ph.D. in geophysics from the California Institute of Technology.

MAYA TOLSTOY is an associate professor in the Department of Earth and Environmental Sciences at Lamont-Doherty Earth Observatory (LDEO) of Columbia University in New York. She is a marine geophysicist specializing in seafloor earthquakes and volcanoes. She has worked extensively on the structure and seismicity associated with mid-ocean ridges and, in particular, how earthquakes in this environment can be used to illuminate hydrothermal and magmatic processes. In addition, she has worked on hydroacoustic signals in the ocean including the Great Sumatra Andaman earthquake, as well as anthropogenic noise. Her work on the East Pacific Rise has been featured in the National Science Foundation's annual report to congress and year in review, and has also been recognized with an accomplishment based renewal grant. Dr. Tolstoy has extensive seagoing experience having participated in 31 sea-going expeditions for 18 of which she was Chief or Co-Chief Scientist. Additionally, she currently helps oversee the LDEO Ocean Bottom Seismograph Instrument Pool (OBSIP), serves on the Incorporated Research

Institutions for Seismology's OBSIP management council, and is a member of the Cascadia Initiative Expedition Team implementing the Cascadia Amphibious Array community experiment. In 2009 she was one of 47 finalists for NASA's Astronaut selection and is the recipient of the 2009 Wings Worldquest Sea Award honoring women in exploration. Dr. Tolstoy has also done extensive outreach work to communicate the excitement and importance of earth science to non-science audiences. She holds a B.Sc. Honors in geophysics from the University of Edinburgh and a Ph.D. in earth science from Scripps Institution of Oceanography, UCSD.

JEROEN TROMP is a seismologist, Blair Professor of Geology, Professor of Applied and Computational Mathematics, and Associate Director of the Princeton Institute for Computational Science. He joined the Princeton faculty in 2008. He was on the Harvard faculty from 1992 until 2000, where he went through the ranks as assistant, associate and full professor. He was the Eleanor and John McMillan Professor of Geophysics at the California Institute of Technology, where he was Director of the Seismological Laboratory from 2003 to 2008. Tromp's main research interests are in theoretical and computational seismology, including simulations of acoustic, (an)elastic, and poroelastic seismic wave propagation on local, regional, and global scales. The current focus of his research involves imaging Earth's interior based on spectral-element and adjoint methods. Tromp received his B.Sc. in geophysics from the University of Utrecht in 1988 and holds an M.S. (1990) and Ph.D. (1992) from Princeton, where he worked under the tutelage of the late F.A. Dahlen. He received the Macelwane Medal of the American Geophysical Union in 1999, a Gordon Bell Award in 2003, and the Beno Gutenberg Medal of the European Geophysical Union in 2013. He is a corresponding member of the Royal Netherlands Academy of Sciences.

WILLIAM (BILL) R. WALTER is a research geophysicist at the Lawrence Livermore National Laboratory (LLNL). Bill is the LLNL lab leader for the Ground-Based Nuclear Explosion Monitoring (GNEM) R&D and the Nuclear Test Limitation (NTL) programs. He is also the LLNL point of contact for the Source Physics Experiments (SPE). He served on the Seismic Subcommittee for the National Academy of Sciences Panel that issued a 2012 report updating the technical issues related to the Comprehensive Nuclear-Test-Ban Treaty (CTBT). In graduate school he collected seismic data from U.S. nuclear tests in Nevada and from the 1988 Soviet Joint Verification Experiment in what is now Kazakhstan. He is the author or co-author of more than 65 peer-reviewed scientific papers. His research areas include: geophysics and seismology, seismic source physics, earth structure, tectonics, treaty verification and related policy issues. Bill received a B.A. in physics from Middlebury College in 1984, a M.S. in physics from UCSD in 1986, and a Ph.D. in geophysics from the University of Nevada, Reno in 1991. After working at LLNL for two summers while in graduate school, he joined LLNL as a postdoc in 1991.

SHERILYN WILLIAMS-STROUD is a senior geological advisor with California Resources Corporation (formerly Occidental Oil and Gas). She is an expert in fracture modeling, reservoir stress and strain analysis, and rock fracture mechanics with applications to oil and gas exploration and production and unconventional resources. She began her career in 1988 at the U.S. Geological Survey first doing research in the area of evaporate geochemistry in the Energy Resources Branch, and also working on fracture characterization for the Yucca Mountain Project. She stepped out of research for about two years into the position of Staff Scientist for Program, where she oversaw the USGS Central Region facilities; The Core Research Center, the

Nuclear Reactor Facility, and the Microbeam Lab. In 1998 she returned to research when she moved to the private sector as a senior research scientist with ChevronTexaco Exploration and Production Technology, during which time she also taught geology as an adjunct at the University of Houston. She was a full time faculty member at Whittier College when she joined Midland Valley Exploration, a software and consulting company in Glasgow, Scotland, as the Geology Team Leader and the technical lead for development of their fracture modeling module. She left Midland Valley in 2008 to join MicroSeismic, Inc., where she partnered with the chief geophysicist to develop a patented methodology to integrate microseismic data into geologic interpretations for fracture modeling of microseismic results for use in reservoir simulation. Although her recent publications are primarily in the area of fracture analysis and modeling, she still finds time to continue to collaborate on evaporite geochemistry research. Dr. Williams-Stroud received her B.A. in geology from Oberlin College in 1981, and her M.A. in 1984 and Ph.D. in 1988 in structural geology, both from The Johns Hopkins University.

Committee on Seismology and Geodynamics Meeting
National Academies Keck Center
500 Fifth Street, NW
Washington, D.C. 20001

If you plan to attend the meeting, please RSVP to Courtney Gibbs at cgibbs@nas.edu.

AGENDA

Wednesday, May 20 - Room 106

CLOSED SESSION (Committee and NRC Staff Only)

8:30 a.m. - 12:45 p.m.

OPEN SESSION ON TOPICS OF INTEREST FOR SPONSORING AGENCIES AND COSG (Everyone Welcome)

1:00 p.m. Panel discussion with COSG Sponsors *Richard Allen, COSG Chair*

- *David Applegate, USGS*
- *Ben Phillips, NASA*
- *Leonard Johnson, NSF*

4:00 p.m. Break, open session adjourns

To join remotely, please follow the instructions below:

Meeting information

Topic: COSG Spring 2015
Date: Wednesday, May 20, 2015
Time: 1:00 pm, Eastern Daylight Time (New York, GMT-04:00)
Meeting Number: 749 080 753
Meeting Password: COSG2015

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